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ABSIRACT

This speech compares the air conditicning requirements cf high-rise cffice buildings with those of large centralized school complexes. A description of one particular air conditioning system provides informatich about the system's arrangement, functions, performance efficiency, and cost effectiveness. (MLF)

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THERMAL ENVIRONMENT FOR CLASSROOMS

Central System Approach to Air Conditioning

by

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THERMAL ENVIRONMENT FOR CLASSROOMS

Central System Approach to Air Conditioning

I. In spite of differences in physical appearance, location, and function, modern high rise office buildings and large centralized school complexes have a surprising similarity in air conditioning requirements. We can enumerate them as follows:

a) Large interior areas with high lighting loads which need cooling year 'round to maintain comfort.

b) Air filtration and ventilation standards are high.

c) Built-in flexibility for future changes in partition layout and space function is vital.

d) Sound levels must be kept within acceptable limits.

e) Potential for individual temperature control of small to moderate sized areas must be incorporated.

f) Year 'round control of humidity level is desirable.

g) Owning and operation costs are a major consideration.

Since central air conditioning systems are the overwhelming choice for large office buildings, we might ask ourselves why they are not more widely applied in school construction?

II. What leads building owners and/or their engineers to choose a central system of air conditioning in the first place? Of all possible criteria, I would say the two major factors are the size of the structure and its anticipated life cycle, and there certainly is a minimum point where the economics would tend to eliminate a central system completely. For schools, it would appear that this is in the area of 70,000 sq. ft. But what about the question of equipment life, or owning and operating costs over a period of years? Or,

how about satisfactory control of space conditions, including sound levels? Here, we get into that elusive area designated as "Quality." We all know that this is a very tough concept to pin down because it is a relative thing, and because no manufacturer likes to admit that he makes anything other than high quality products.

III. To illustrate, let us project ourselves backward in time to the early 1950's - when air conditioning was still a comparatively new experience for most people. At that time, a very common solution to the problem of year 'round heating and air conditioning for small stores or suburban type office buildings was to take a direct gas-fired unit heater, hang it from the ceiling, and install a 3 or 5-ton packaged air conditioning unit on the floor. In winter, you blew air through the gas-fired unit heater, and in summer you blew air through the packaged air conditioner right into the space. For a deluxe installation, you might even provide ductwork and hide the equipment behind a partition. This did the job fairly well if one wasn't too particular about close temperature control, good filtration, or sound levels, and if you weren't planning for more than 6 - 10 years' life. With this approach, you could do the job for less than half the cost of a high quality central system using centrifugal or absorption water chillers, and a hot water or steam boiler. Even though the packaged equipment was widely used in providing cooling to existing buildings, most engineers were aware of the shortcomings of this approach and specified central systems when budget considerations permitted. Incidentally, in the 1950's, centrifugal water chilling equipment sold for about $125 a ton and required a great amount of additional field labor for installation, and massive concrete bases to support the various components.

IV. Moving up to the present day, 20 years later, we note that the direct expansion reciprocating chilling packages have been combined with the direct-fired gas furnaces, enclosed in attractive steel and aluminum boxes, so that they can be mounted outdoors on the roof. This also facilitates the use of air cooled condensing for the refrigerant. Interestingly enough, we find the same reciprocating compressors of 20 years ago still being applied, and they still require approximately 2 kilowatts of electrical energy per ton of cooling. The heat source, in most cases, is an adaptation of the direct gas-fired unit heater. In contrast, the centrifugal water chilling machines now used with the central systems have undergone a complete metamorphosis. They are now extremely compact complete factory-assembled packages, requiring a minimum of field installation labor. Massive concrete bases are no longer required. Their control systems incorporate the latest in solid state technology, and their ability to produce cooling at an economical rate of power consumption is even better than it was 20 years ago, especially at light loads. It is now in the range of 1 kilowatt per ton of cooling, or less. The cost is now about $60 per ton of cooling, or most exactly half of what it was 20 years before. In this same period, great advances have been made in room terminal units and their control, and in the large centrifugal fans, which are the heart of the air moving portion of the system.

V. With these facts as a background, I would like to proceed with a brief description of the particular air conditioning system which we, at Carrier, feel is the best all-around central system for school buildings, as well as other larger building applications. I would like to show you how this system is arranged, how it functions, and describe how this system provides reasonable first cost, excellent functional performance, and low owning and operating costs.

a) First, let us consider how it would apply to a typical classroom. Remember that what most occupied spaces in a large modern school require is not so much heating systems with supplementary cooling, but cooling systems with supplementary heating. Cooled and dehumidified air is supplied from a central apparatus through variable volume outlets in the ceiling of the room. Because of the high induction ratio and the draft-free operation of this outlet, temperature differential between the supply air and room temperature can be 25° or higher. This means that smaller quantities of air are required to handle the maximum cooling which, in turn, results in savings in first cost and in operating costs.

b) Self-contained thermostats incorporated in the outlets themselves (one thermostat can control several outlets) match the air supply to the space cooling load automatically by increasing or decreasing the amount of air supplied. This provides excellent control of both room temperature and humidity, even at light loads. At the same time, air circulation is maintained and drafts are avoided.

c) At the central apparatus, fan output is controlled by variable fan inlet vanes or dampers to maintain approximately constant static pressure in the duct system. This need not be a precise control, but it has a two-fold purpose. First of all, it avoids a buildup of excessive static pressure in the system which could occur when a large number of the variable volume outlets are throttled. The performance of the outlets is compromised if pressures exceed certain limits. The principal reason for fan control of CFM, however, is to capitalize on the opportunity to reduce fan and refrigeration horsepower requirements when the building is calling for less than maximum cooling loads. This is over 90% of

the operating hours. In the past, most of us have been concerned more with refrigeration machine power requirements, but the fact is that fan energy is a much bigger item than refrigeration horsepower, since the fan runs continually during all seasons.

d) Outside and return air dampers can be sized and controlled to provide outside air for free cooling when outside air temperatures drop to 50°F. Another approach would be to restrict outside air quantity to the minimum ventilation requirements and use refrigeration machines to reclaim interior heat for the heating of perimeter areas.

e) Since an entire building can be served from one or two large central apparatuses, high quality, efficient filtration equipment can be justified for the treatment of the air supplied to the building. Maintenance of the filters is then centralized and remote from any occupied areas, which should result in savings in filter maintenance expense.

f) The supply air is cooled and dehumidified in a water coil supplied with chilled water from a central absorption or centrifugal water chiller. Because of the wide possible variations in air supply volume, DX systems can be used, but multiple circuits or back pressure regulators must be provided. On the other hand, there is no need to modulate the flow of chilled water through the water coil, so there are inherent savings in control expense for this portion of the system.

g) Since this is a "cooling only" system, whatever heat required is provided by a separate system which may be simple hydronic or electric resistance baseboard, or an all-air reheat system. Temperature control for the heating is generally a simple programming of water temperature

or electric wattage in response to outside air temperatures, as related to the calculated heat loss of the building.

VI. In addition to owning and operating costs savings, the functional characteristics of this system bring about opportunities for further economies when partition layouts are changed or load requirements for a particular space increase or decrease. Each of the Moduline outlets has its own built-in volume regulator and initial balancing or rebalancing is accomplished simply by setting a dial. Units can also be individually controlled by their own thermostat or these self-contained thermostats can be easily and simply moved from one outlet to another. Several outlets may be controlled from one thermostat. These changes can be handled by the school district's own maintenance personnel if desired, since special skills are not necessary.

VII. From experience reported to date, it appears that operating and maintenance costs on this system are 20-30% less than packaged multizone or central double-duct systems -- 25-35% less than constant volume reheat systems. This is a result of the higher efficiencies of the central refrigeration equipment at both full and part loads, the ability of the system to reduce fan energy requirements by constantly matching the air quantity circulated to the load requirements of the building, and finally, by reduction in maintenance costs through centralizing equipment and filter maintenance at one or two central locations.

VIII. In the area of first costs, from information now available, we can state that a complete heating and air conditioning system using this approach can be

installed for a first cost of approximately $3 - $4 per sq. ft. in buildings of 70 or 80,000 sq. ft. or larger. These are 1970 figures. In the 1950's, a high quality central system cost twice as much as a packaged unitary system using reciprocating, direct expansion cooling, and direct gas-fired heating. Today, with the variable volume Moduline System, the differential in first cost is less than 50%. When we consider this fact, along with the reality of the savings in maintenance and operating costs possible with the Variable Volume Moduline System, the choice of high quality central systems for school air conditioning seems most logical for the 1970's.